APPENDIX B

COASTAL PROCESSES STUDY EXAMPLE--OCEANSIDE, CALIFORNIA

B-1. Example. To illustrate site characterization concepts, a discussion of the site characterization associated with planning an experimental sand bypassing operation at Oceanside, California, is presented. The majority of the information in this example is from Moffatt & Nichol, Engineers (1984). The city of Oceanside is located 80 miles southeast of Los Angeles. A map and a photograph of the project site are shown in Figures B-1 and B-2. The north jetty was originally constructed in 1943 and extended in 1953 to protect the Del Mar Boat Basin and reduce channel shoaling. In the early 1960's, the city of Oceanside constructed Oceanside Harbor, and the Corps added the south jetty.

B-2. Problems at Oceanside. Erosion on Oceanside Beach accelerated immediately after initial jetty construction and continues to be a problem. Shoaling of the entrance channel and harbor also remains a problem. To help reduce erosion of Oceanside Beach, all material dredged from the harbor has been placed on the beach since 1957. In a study of the area, Hales (1978) concluded: "The problems at Oceanside seem to have been caused by a combination of factors: (1) the original construction of the Del Mar Boat Basin jetties during 1942-43 (which traps the net southerly littoral drift in the north jetty fillet and in the entrance channel); (2) a prolonged period of drought causing a withholding of the natural amount of littoral material; and

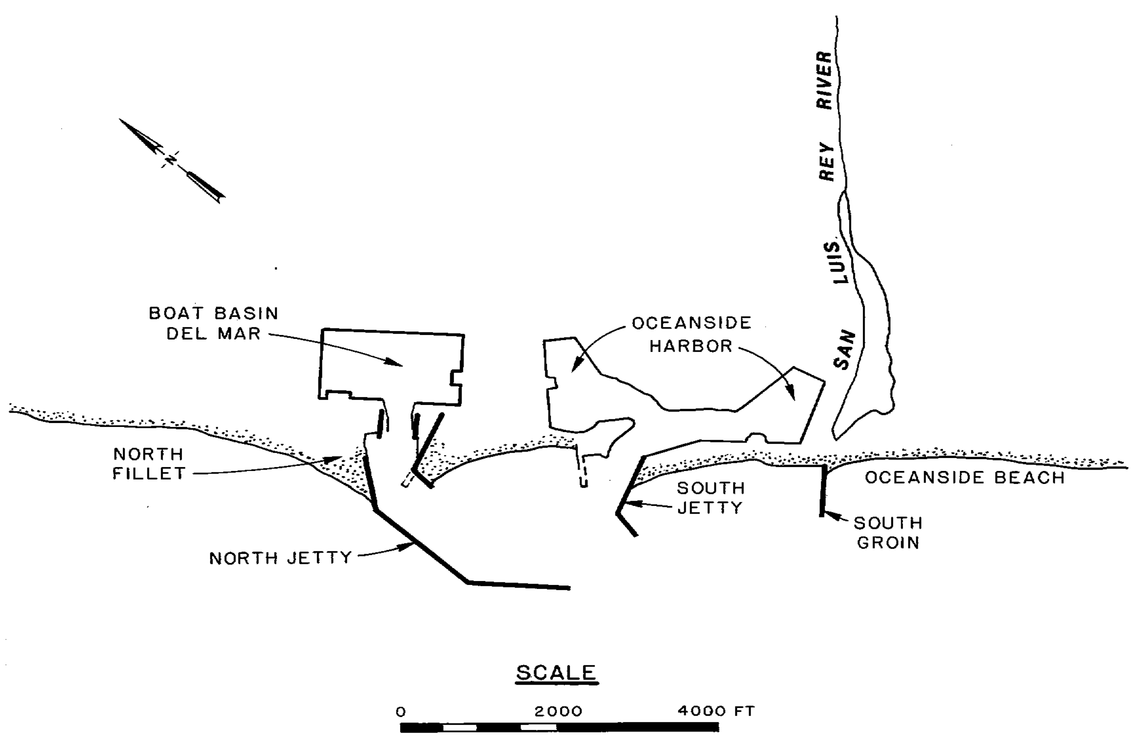


Figure B-1. Bypassing site at Oceanside, California

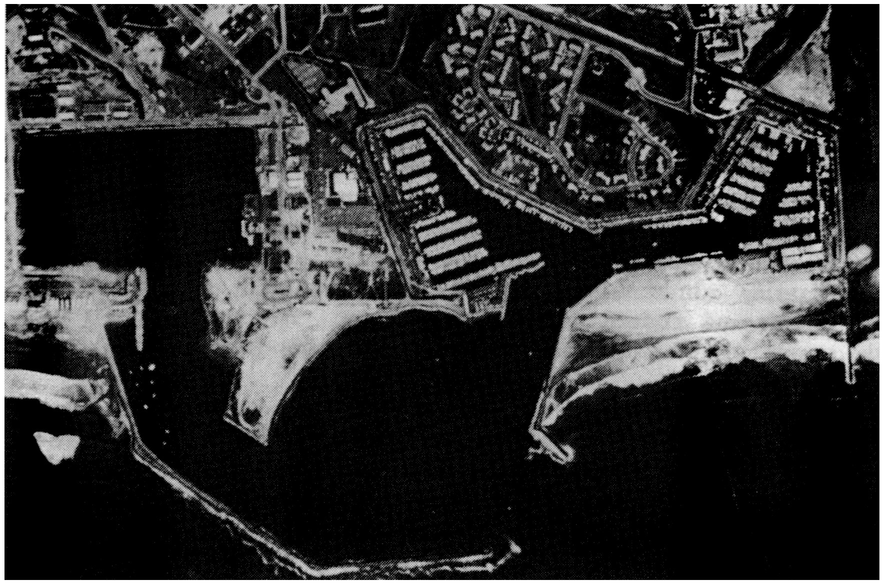


Figure B-2. Aerial photograph of Del Mar Boat Basin and Oceanside Harbor, 1 February 1983

(3) to some extent, the flood retaining structures built along the San Luis Rey and Santa Margarita Rivers. These two rivers once provided major sources of beach sediment for the littoral cell at Oceanside."

B-3. Site Characteristic Considerations. The primary purpose of the experimental sand bypassing operation at Oceanside is to reduce maintenance dredging in the entrance channel. A secondary purpose of the operation is to reduce erosion on the beach south of the harbor. During design of the sand bypassing operation at Oceanside, the following site characteristics were considered. The material included is selective and summarized because of space limitations, but it does include a majority of the topics discussed in Chapter 4.

a. Waves. Good quality wave data are available for Oceanside. A wave gage, part of the Coastal Data Information Program, was located near Oceanside Pier in 32 feet of water in 1976 and continues to operate. Data from the gage, shown in Figure B-3, were used to calculate operational conditions. To determine design waves at the site, significant storm wave data from hind-casted storms were refracted onto shore using procedures from the Shore Protection Manual (SPM) (1984), as shown in Table B-1 (Marine Advisors 1960). From statistical analysis using the extremal type I distribution (Issacson and Mackenzie 1981), wave heights for a 15-year return period were calculated (planned experiment life is 5 years). The design and operational wave conditions for various locations at the site are shown in Figure B-4. Operational waves are those wave conditions in which the system is expected to be fully operational.

b. Currents. Because of sheltering effects from offshore islands, the primary directions of wave approach are from the northwest during the fall and winter and from the south during the spring and summer. Currents, resulting

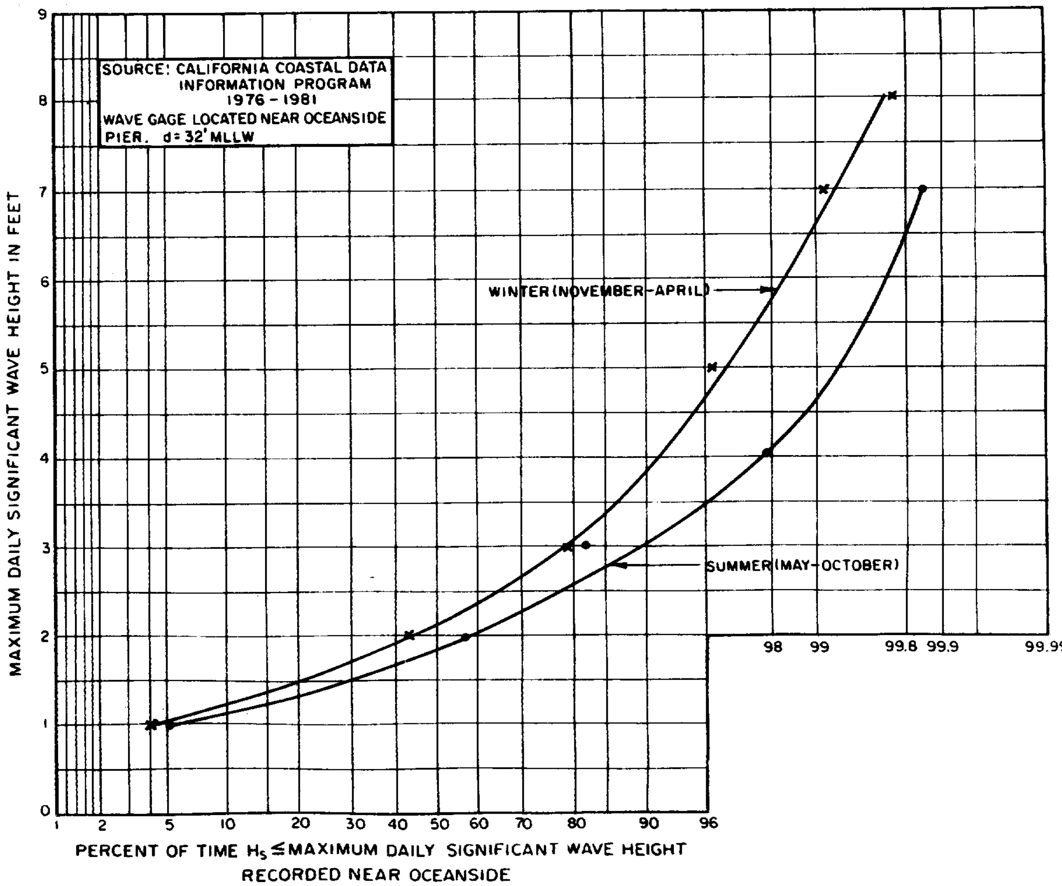


Figure B-3. Distribution of wave heights at Oceanside Pier

primarily from waves because of the small tidal prism, were evaluated from the model studies (Figure B-5) (Curren and Chatham 1980). Note that waves from both the northwest and south produce southwest currents around the tip of the south jetty. This fact becomes more important when directions of sediment transport are discussed later in the example.

c. Littoral Drift. Probably the most important aspect of site characterization is estimating the amount and direction of littoral drift. Oceanside is somewhat unusual in that littoral drift estimates are available from a relatively large number of sources. However, the range of these estimates (Table B-2) shows the difficulty in determining these parameters and the need for good engineering judgment in deducing values to use for design.

d. Sediment Transport Rate. The pre-1960 estimate (Moffatt & Nichol, Engineers 1984) in Table B-2 was based on volumetric analysis of the shoreline. The Marine Advisors' (1960) study computed sediment transport using an empirical longshore transport formula and available wave data. Hales (1978) computed his values by applying an empirical longshore transport formula to hindcast wave data. Weggel and Clark (1983) used a sediment budget approach and reduced Hales' longshore sediment transport to remove the effects of the

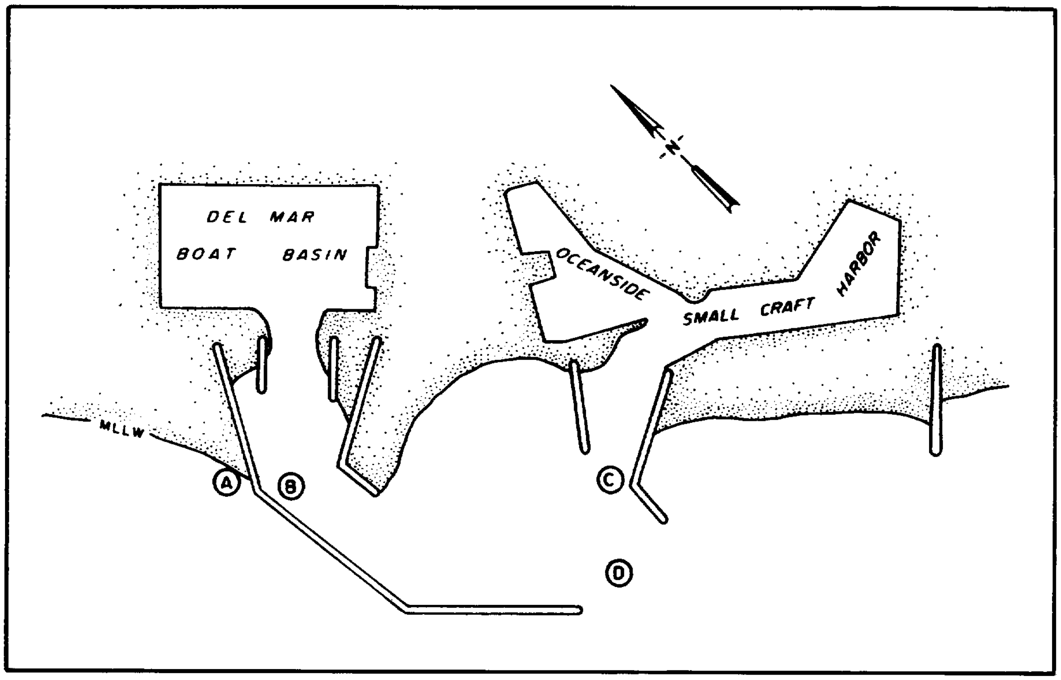
Table B-1

Design Significant Wave Data at Oceanside

Storm Date	Significant Breaker Height feet	Significant Period seconds	Breaker Direction degrees
15-25 September 1939	24.7	14.0	219
9-10 March 1904	17.2	12.0	226
28-30 January 1915	16.1	11.8	221
8-10 March 1912	14.7	11.5	238
6-8 January 1953	14.4	15.0	231
1-2 February 1926	13.3	16.0	231
20-23 January 1943	12.8	10.8	215
1-3 February 1915	12.7	12.4	238
26-28 January 1916	12.6	9.6	233
13-14 March 1952	11.5	11.7	226
6-12 December 1936	10.6	16.4	232
16-17 December 1914	10.6	9.9	215
6-8 April 1926	10.1	13.8	235

simultaneous occurrence of sea and swell. A slope-array wave gage that produces height and direction data was operated at Oceanside from 1979 through 1981. Maximum potential transport rates calculated from the data were 5,280 cubic yards per day to the south and 5,700 cubic yards per day to the north. By comparing data from the slope array gage with dredging records over the same period, Seymour* estimated that the harbor can trap up to 50 percent of the gross transport. Based on the amount of material dredged (Table B-3), the US Army Engineer District, Los Angeles, estimated the maximum average trapping rate to be 48,000 cubic yards per month from July 1967 to March 1968, which corresponds to a maximum gross transport rate of 1,200,000 cubic yards per year. Using the same logic and 300,000 cubic yards per year as the average annual amount of material dredged from July 1967 to June 1981, it is estimated that the average annual gross longshore transport rate would be 600,000 cubic yards per year. However, if the amount of gross transport

* R. J. Seymour, 1981, "Evaluation of Sand Bypassing at Oceanside, California," Unpublished report prepared for the US Army Engineer District, Los Angeles, Los Angeles, CA.



Summary of Design and Operational Waves

Location	Water[1] Depth (ft)	Wave Period (sec)	Wave Height (ft)	Type	Operational Conditions
A	13	14	10	Breaking	Surf zone extends to angle point of north breakwater.
B	10	3-14	3	Non-breaking	Subject to boat wakes and overtopping waves.
C	29	14	14	Non-breaking	Waves may break at times.
D	29	14	14	Non-breaking	Waves may break at times. Operational waves exceed H_s = 3 ft, 10 to 20 percent of the time.

(1) Includes +7-foot MLLW design water elevation

Figure B-4. Summary of design and operational wave heights and locations

trapped by the harbor is assumed to be a maximum of 50 percent, then the average annual longshore transport is likely to be higher than 600,000 cubic yards per year and approaches the other values. The general conclusion reached from these data is that net transport is to the south, and the net longshore transport rate is between 100,000 and 200,000 cubic yards per year.

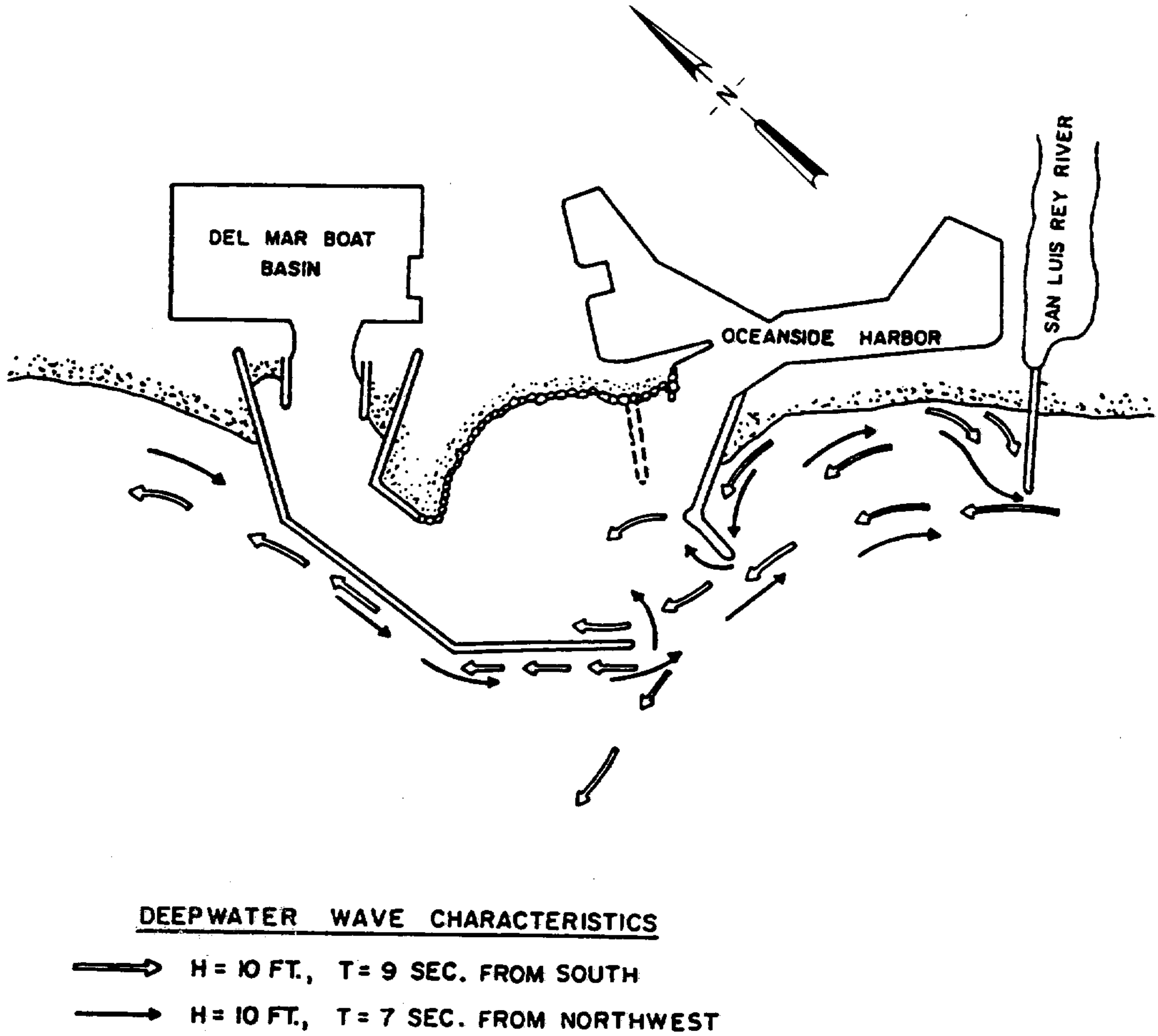


Figure B-5. Wave-induced current patterns

Table B-2

Summary of Sediment Transport Estimates
for Oceanside, California

Source	Gross Transport cy/yr	Net Transport cy/yr
Pre-1960	1,080,000	380,000 S
Marine Advisors (1960)	1,305,000	215,000 S
Hales (1978)	1,200,000	102,000 S
Weggel and Clark (1983)	875,000	77,000 S

Table B-3

Dredging History, Oceanside, California,

Harbor and Entrance Channel

Starting Date	Completion Date	Disposal Area	Approximate Dredge Quantitiy cubic yards
May 1942	Aug 1944	Inland Fill	1,500,000
Apr 1945	Jun 1945	Inland Fill	219,000
Apr 1957	May 1958	6th to 9th St.	800,000
Aug 1960	Aug 1960	6th to 9th St.	17,500
Sep 1960	Oct 1960	6th to 9th St.	23,700
Jan 1961	May 1961	6th to 9th St.	222,350
Aug 1961	Dec 1961	6th to 9th St.	258,800
Mar 1962	Feb 1963	9th St. to Loma Alta Cr.	3,810,700*
Aug 1965	Aug 1965	9th to 3rd St.	111,400
Mar 1966	Apr 1966	3rd St. to Minn. Ave.	684,000
Jul 1967	Jul 1967	3rd St. to Tyson St.	177,900
Mar 1968	Jun 1968	San Luis Rey to Wis. Ave.	433,900
Jul 1969	Sep 1969	San Luis Rey to 3rd St.	353,000
Apr 1971	Jul 1971	3rd St. to Wis. Ave.	551,000
Jun 1973	Jul 1973	Tyson to Hays St.	434,100
Oct 1974	Jan 1975	Pine to Witherby St.	559,750
May 1976	Jul 1976	Ash to Witherby St.	550,000
Aug 1977	Feb 1978	Ash to Witherby St.	318,550
Feb 1981	Jun 1981	3rd St. to Buccaneer	463,000

* Construction of Oceanside Harbor.

The gross transport was estimated as between 1,000,000 and 1,200,000 cubic yards per year. Accretion amounts in the north fillet and offshore of the north breakwater combined with erosion south of the San Luis Rey River support these conclusions.

e. Bypassing Capacity. While determining the annual transport rates is important, the bypassing capacity of a plant is more realistically based on shorter periods. The length of the time period depends on the type of plant and capacity of the storage area. At Oceanside, the daily shoaling rate of the entrance channel during the peak shoaling season was chosen as the basis for the design bypassing capacity.

f. Average Daily Accretion Rates. Average daily shoaling rates as determined by computing the volume differences between surveys are displayed in Table B-4. The highest average daily rates occur between March and

Table B-4

Oceanside Harbor Survey Study

Dates of First and Second Surveys	Season	Days Between Surveys	Total Volume Change cu yd	Average Daily Rate cu yd/day	Hales' Potential Gross for Period cu yd
5/21/64-5/15/65	Yearly	359	191,389	533	1,157,731
3/15/70-4/12-71	Yearly	393	292,870	745	1,258,174
10/17/63-5/21/64	Fall, Winter	216	-37,398	-173	512,365
9/12/69-3/15-70	Fall, Winter	184	38,259	208	396,802
11/1/72-5/1/73	Fall, Winter	181	46,954	259	372,799
4/15/66-9/10/66	Spring, Summer	148	238,065	1,609	696,299
3/15/63-10/17/63	Spring, Summer	216	258,129	1,195	896,046
6/1/72-11/1/72	Summer, Fall	153	209,824	1,371	649,872
8/1/72-6/1/72	Fall, Winter, Spring	304	74,528	245	860,057
7/10/73-2/26/74	Summer, Fall, Winter	231	144,722	627	654,205

October. A method has been devised to analyze surveys covering the same or overlapping time periods in different years to find maximum average shoaling rates. Table B-5 shows the results. The largest average accretion rates were June through August, ranging from 2,300 to 3,400 cubic yards per day. The actual values would be expected to be higher or lower than these values on a given day.

g. Maximum Daily Accretion Rates. The maximum daily accretion rates (2,300 to 3,400 cubic yards per day) agree in magnitude with data collected by several investigators. Hales (1978) obtained a maximum longshore transport rate of 5,737 cubic yards per day, while Castel and Seymour (1982) determined

Table B-5

Accretion Rates* at Oceanside Harbor

Mar-May	Jun-Aug	Aug-Oct
630	2,271	14
-262	2,291	762
630	3,418	14

* Cubic yards per day.

the maximum rate to be 5,800 cubic yards per day; and Seymour* obtained a maximum rate of 8,500 cubic yards per day. Based on these potential figures, after reducing them by the assumption that the harbor traps 50 percent or less of gross longshore transport, the maximum daily influx to the harbor would be 2,900 to 4,300 cubic yards. The daily rates presented above are based on averages over a month or more. The maximum daily rate can be several times higher than the average rate. For example, using the following equation from the SPM:

$$P_{ls} = 32.1\ (H_{so})^{5/2} \sin 2\ \alpha\ b \text{ (ft-lb/sec/ft of beach front)} \qquad \text{(B-1)}$$

(where s = significant wave height and o = deepwater value) for calculating P_{ls} from breaking waves and the relation (from the SPM):

$$Q = 7{,}500(P_{ls}) \qquad \text{(B-2)}$$

Breaking waves 10 feet high with a breaker angle of 10 degrees lasting 4 hours would have a potential longshore transport of 11,900 cubic yards. Even 4-foot waves with a breaker angle of 8 degrees have the potential to transport 1,000 cubic yards in 4 hours. This fact implies that maximum daily accretion rates may be much greater than the average daily rates estimated by the methods discussed above. However, since the long-term average shoaling rate of the harbor is less than 1,000 cubic yards per day over the year (261,000 cubic yards per 365 days), a design value of 3,000 cubic yards per day appears to be a reasonable compromise.

h. Volume Change Analysis. Analysis of volume change information from surveys shows that sand moves into the channel from the south side (Figure 4-7). This conclusion is strengthened by the current and sediment movement patterns from model studies (Figures B-5 and 4-9). Therefore, during the design of the experimental bypassing plant, it was decided to concentrate the channel sand removal capability on the south side of the entrance channel.

i. Grain Size Analysis. Grain size analysis of the sediments at Oceanside was made to determine their suitability for beach nourishment and pumping characteristics. In addition, subsurface cores were taken to determine the depth to bedrock and the presence of cobbles or clay. The results of the surface sampling program are shown in Figure B-6. Coarser sands are

* Seymour, op. cit.

trapped in the north fillet and offshore of the north breakwater, probably because of higher wave energy at these locations. Finer sand is transported into the harbor. The coarse sand at the north fillet ultimately influenced the bypass system's hydraulics, requiring the addition of a booster to pump the north jetty sand to the more distant discharge points.

j. Environmental Considerations. Environmental constraints became particularly important on the south side of the harbor. This is a densely populated area with condominiums and a marina. Bypassing operations in the area have to be as unobtrusive as possible to avoid complaints from local residents. Similarly, the beach at Oceanside is heavily used, so the beach discharge lines had to be buried and the discharge vaults protected from vandalism. The possibility of the discharge pipeline's being exposed by storm wave erosion was also considered in the system design. Maximum amounts of historical erosion were determined, and the pipeline was buried below these elevations.

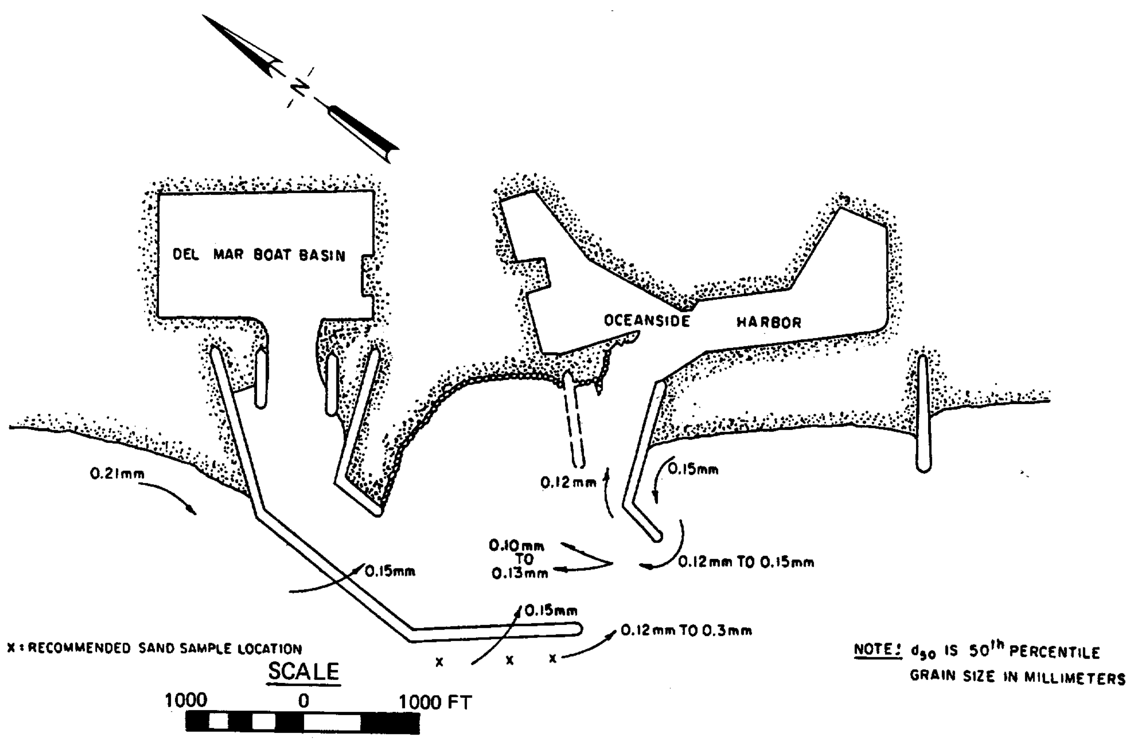


Figure B-6. Design d_{50} grain size of influx sediment